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The Mysore Coffee Experiment Station—Bulletin No. 5.

DEPARTMENT OF AGRICULTURE

MYSORE STATE

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ANNUAL REPORT OF THE COFFEE SCIENTIFIC OFFICER, 1930-1931

BY

W. WILSON MAYNE, B.Sc.

Scientific Officer to the United Planters' Association of Southern India

BANGALORE:
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FIG. 1.

Robusta coffee plant killed by *Fomes lamœnsis.*

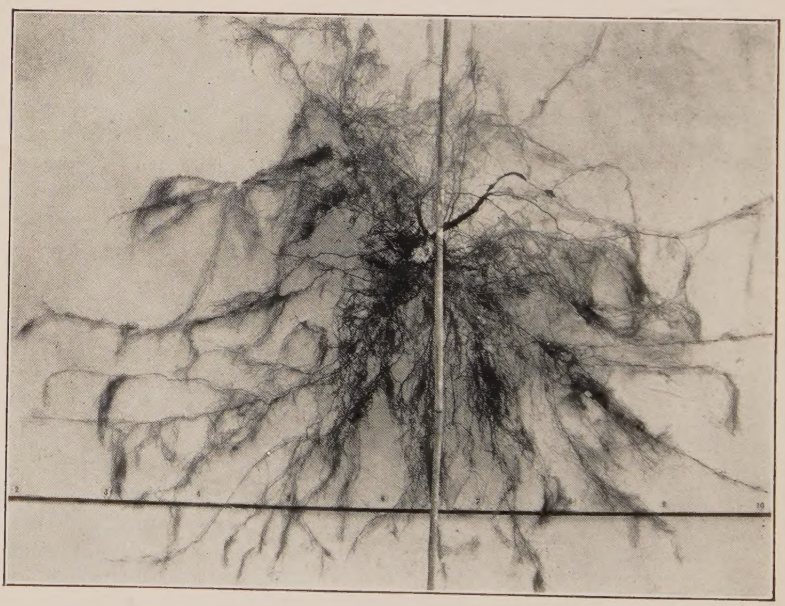

FIG. 2.

Root system of plant shown in Figure 1 viewed from above. The Blackened root to the right at two o'clock is the one which was stuck to the decaying stump.

FOREWORD.

THE previous two annual reports giving an account of Mr. Mayne's work have been published as appendices to the Proceedings of the United Planters' Association of Southern India. The report for 1930-31 contains information of such general interest to coffee planters in South India that its separate publication seems to me desirable. The approval of the Executive Committee of the United Planters' Association of Southern India for the publication of the report as a bulletin of the Coffee Experiment Station has been obtained.

July, 1931. LESLIE C. COLEMAN.

ANNUAL REPORT OF THE COFFEE SCIENTIFIC OFFICER, 1930-31.

I have the honour to present the administration report of the Coffee Scientific Officer for the year ending March 31st, 1931, dealing with the work in progress in connection with coffee problems.

As in the previous year, the work has been centred at the Mysore Government Coffee Experiment Station, Balehonnur, under the direction of Dr. L. C. Coleman. Work in co-operation with the officers at the station has been continued and extended in connection with breeding, spraying and miscellaneous problems.

A short tour was made in the Shevaroys in connection with spraying problems during the month of July.

The report comprises as usual a short account of touring work, scientific investigations in progress and general notes on coffee problems which have been raised during the year.

Touring.

At the request of the Shevaroy Planters' Association, a visit of a week's duration was paid to the district to study and advise on spraying problems. The results of the tour, which were of value not only in relation to the special problems of the Shevaroys but also in emphasizing several features in the distribution of Leaf Diseases not previously realized, were embodied in a report submitted through Dr. Coleman.

The main results and conclusions are here presented in summary.

There can be no possible doubt that spraying in the Shevaroys is of great value, both in increasing yields and in enabling the bearing of good crops in years of unfavourable seasonal conditions. The latter advantage is well borne out in the 1930-31 crop. Showers were experienced in February, which forced a partial blossom on unsprayed areas at that time. The set was poor and crops on such

areas were generally low. On the sprayed areas, the early showers did not result in a blossom, the buds remaining dormant until April, when a satisfactory blossom and set were obtained. The sprayed areas alone were bearing a good crop at the time of the tour.

The main problem is the question of the most favourable time for spraying, concerning which there are considerable divergences of opinion in the district. It seemed that these divergences were the result of differences in the conditions on different estates and one of the major differences appeared to be exposure to wind. The question of the importance of wind in determining the rate of increase of Leaf Disease has been dealt with in a separate report shortly to be published, but it may be said here that it appears from detailed observations that, given suitable moisture conditions, a sheltered area will develop an intensive attack of the disease more rapidly than a wind swept one. In the Shevaroys, the support for later spraying, *i.e.* August application, comes from estates where the coffee is exposed to wind, and that for earlier spraying, *i.e.* June application, from sheltered areas. The problem is further complicated by the delay of the flush in the more exposed areas and this may be the main reason for the better results with the later spray in such areas. The two co-operate for, apart from spraying, the reports of the behaviour of the disease showed similar differences in the time of heavy attack. In the sheltered area, the disease is usually noted in July while in the exposed places there is a delay until September.

On the question of materials, opinion is divided, the majority being in favour of Burgundy mixture with Fish Oil Resin Soap as an adhesive. The alternative in use to a much smaller extent is Bordeaux with Resin Soda adhesive. There does not seem to be any noticeable difference in efficiency, though there were no strictly comparable areas seen during the visit. The Burgundy has the advantage of requiring a material—Soda Ash—of more constant composition than the lime marketed in this country. Moreover, the quantity required in the mixture is less than in the case of the lime in Bordeaux. There have been no cases of burning due to excess of the constituents as far as I was able to hear. The subject of adhesives will be dealt with later in the report.

All three of the main types of sprayers were seen in use. Drake and Fletcher's D. S. P. " Headland " sprayer

seems the most satisfactory where road facilities are reasonably good. In other areas, the "Four Oaks" battery sprayer has been found useful. The small Knapsack pressure sprayers are also sometimes used where the D. S. P. cannot be employed but the falling off of pressure is an undesirable feature.

There seemed an opportunity for improvement in the organization of work with the D. S. P. It appeared to be the custom to employ only a small number of barrels,—a mixing barrel, a water barrel and a spraying barrel, the two former being moved when necessary while the last lot of mixture is being sprayed. In some cases, the mixing is done at a central mixing station and the mixture is carried to the spraying barrel. In Mysore, it is usual to increase the number of barrels and to have them spaced out along the road in pairs, one for water and one for the mixture. The water barrels are filled up ahead of the actual sprayers, while the mixture is prepared as required just ahead of the sprayers. Thus, when a move is necessary, the mixture is ready for the immediate recommencement of work. There seems to be less waste of time in making changes of position by this method, while the water carrying coolies are in a large measure working independently of the sprayers. Some economy in water carrying labour might perhaps be effected in this way.

Costs appear to be slightly cheaper than in Mysore, working out at Rs. 17-20 per acre per application, (*i.e.*, for full strength spraying). The number of trees per acre is generally less than in Mysore and at the time of my visit, male coolies were paid slightly less per day.

The spray cover was everywhere thorough and generally even, though less so where the knapsack sprayer was in use. On the whole, one spray per year appears to be sufficient to afford a satisfactory control of the disease.

Investigations.

Coffee Die Back. Progress Report.—Work on the Die Back of coffee has been continued during the year. The importance of environmental conditions and the state of health of the trees has been further emphasized by the observations, but the part played by the fungus which is constantly isolated from diseased shoots is still very obscure.

Of the conditions predisposing trees to the attack of Die Back, defoliation by Leaf Disease takes primary place. It seems that heavy cropping, poor soil and light shade exert their influence through their effects in encouraging leaf fall. As far as the type of Die Back under consideration is concerned, leaf fall appears to be a necessary preliminary. With one exception, cases of dying back of shoots bearing several pairs of leaves have proved to be due to distinct causes, *e.g.*, a branch disease of little importance so far uninvestigated, sundry borers or mechanical damage.

The exception mentioned is a special case in which a shoot bearing several leaves but which lost the apical pair or couple of pairs developed a Die Back at the leafless tip.

In order to study more closely the relationship between leaf fall and Die Back, a series of observations was started in August 1930 on young shoots which had been defoliated by Leaf Disease but which were otherwise green and healthy. One hundred such shoots were labelled on August 14th and their future history followed by observations on September 8th, October 13th and November 24th. By September 8th, 39 had died from Die Back, 2 showed the first signs of the disease, while the remainder were still healthy. On the 13th October, a further 8 were dead and blackened, including the two which showed the first signs of the disease at the previous observation. One more had died by 24th November. The remaining 52 were healthy and had formed one or two more pairs of leaves. This shows that leaflessness in itself is not the cause of the disease.

In connection with the work on Leaf Disease, the results of which are reported elsewhere, the history of a number of young shoots was followed over a much longer period. Out of 167 young shoots in these observations, 112 were dead from Die Back in September 1930, and out of these 112, 99 were either leafless before Die Back symptoms were visible or, on the last date of examination before such symptoms were seen, bore only more or less heavily diseased leaves. The remaining 13 bore a pair of healthy but immature leaves at the tip. In no case of a shoot succumbing to Die Back were there any mature healthy leaves. Of the 55 which survived, 7 were at one stage of their life during the danger period completely devoid of leaf, while many of the remainder bore only

diseased leaves at one time or another during the same period.

Thus it appears that Die Back is associated with defoliation but is not a necessary consequence of such a state.

It was next considered possible that deficiency in available food reserves might be the predisposing cause, and to study this, numerous sections of normal, defoliated and Die Back attacked twigs were cut and tested for starch content. Records were kept of the density of starch grains in the various tissues of the shoots. The number of shoots examined was not sufficient for any definite conclusion to be arrived at, but the indications are that there is a marked deficiency of starch in shoots showing incipient Die Back and in defoliated healthy shoots, as compared with the amount in the leafy shoots. No sharp distinction can be drawn, however, between the amounts found in healthy leafless shoots and incipient Die Back shoots on the number examined. This work will be continued when material again becomes available.

In the laboratory, fresh isolations from diseased shoots have been carried out and, as in the previous year, a *Colletotrichum* (*Glæosporium*) was regularly recovered.

Attempts at inoculation were made during the year on young potted plants which had been kept in the dark to exhaust the food reserves. Unfortunately, the time required to exhaust the reserves was considerable and a large number of plants were destroyed by rats. Two small series of inoculations were set up with the remainder from two separate series of pots. In one, no result was obtained, while in the other, one of the inoculated plants developed a diseased area on one of the minute tip leaves, from which the *Colletotrichum* was recovered. The fungus proceeded no further, however, and the typical symptoms did not appear. Further work along these lines is planned for the future.

In the meantime, as far as practical measures are concerned Die Back can be largely controlled by controlling Leaf Disease as was pointed out in the report for 1929-30. It may be remarked that the area which was examined for Die Back in 1929 (Report of the Coffee Scientific Officer 1929-30, p. 13) was sprayed twice, before and after the monsoon in 1930 and in spite of the fact that the year was a bad one for both Leaf Disease and Monsoon Die Back, the area was almost free of the

disease. Efficient protection against Leaf Disease by spraying must therefore take first place in the control measures against Die Back. This applies especially to monsoon Die Back but it seems that hot weather Die Back can be similarly controlled for though it shows up at a period when Leaf Disease is not active, the conditions that lay the plants open to attack are those of a late Leaf Disease attack, *i.e.*, in December. It was noted during the year that leafless or almost leafless branches with considerable quantities of bud remained apparently healthy through the early part of the year and then developed Die Back at the time of the first showers.

Attention to cultural practices which keep the trees in good health will help in the control of Die Back in so far as they enable trees to withstand defoliation. While it does not seem that such practices can produce a resistance to Leaf Disease attack, they can enable the trees to withstand the effects of such attacks. Healthy coffee requires a more severe intensity of Leaf Disease to cause leaf fall than unhealthy coffee. It must be emphasized that in areas where Leaf Disease and Die Back are severe, cultural practices alone are insufficient to give adequate control.

Root Diseases. Progress Report.—Attention to root diseases has been confined to the commencement of a detailed study of Brown Root Disease usually attributed to the action of *Fomes Lamaœnsis* Murr. This is by far the most common cause of the death of coffee plants by root disease and it was felt that it would repay close investigation.

The general characters of the disease have been frequently described in publications dealing with the diseases of woody crops in the tropics of Asia and Africa. The chief feature is the development of a thick crust of adherent earth and small stones around the woody roots. On the root surface and in pockets in the earth crust are found quantities of fungus mycelium which may be in the form of tawny brown woolly hyphæ or black or brown crusts which may be either smooth or powdery. The wood of the roots is very brittle as a result of the attack and they readily snap off in the ground when the diseased plant is removed. In the interior of the root, dark brown to black, wavy lines are to be seen. The structure of these lines has not been clearly worked out but they appear to consist of tangled fungus hyphæ together with a brown pigment.

The first work was directed to obtain the fungus in culture. Isolations were made from the diseased wood and from the cortical region of diseased roots and a fungus growth was obtained very constantly from the roots of both diseased tea and coffee plants.

In the absence of any form of reproductive organs both in the cultures and on the diseased plants, the task of deciding whether the fungus obtained was in fact the same as that responsible for the tawny brown mycelium and the black crusts on the diseased roots was somewhat difficult.

The growth in culture on Potato Dextrose Agar was at first sparse and superficial with very small quantities of aerial mycelium. The hyphae were colourless and showed no striking features in the early stages. As the cultures got older, aerial mycelium became more profuse and at times filled the tubes and at the same time the older growth began to turn brown. Later, the aerial growth became reduced and the surface of the culture presented, first a brownish powdery appearance and then black crusts were formed.

While the cultures showed many features reminiscent of the growth found on the roots, it was only on microscopic examination of hyphae from diseased roots and those from cultures that satisfactory evidence of identity was obtained. The dark brown to black crusts on the root were found to contain fungus hyphae of a peculiar form, which gave the surface a powdery appearance. These hyphae were dark brown in colour and bore numerous very short branches developing in clumps very close together, each branch being swollen and rounded at the tip. Identical hyphae were found in the cultures.

The pure cultures of the fungus having been obtained, a number of blocks of coffee wood were sterilized and inoculated with portions of actively growing mycelium. The fungus grew rapidly on the blocks and enveloped the whole in mycelium which was first colourless and later turned tawny brown and finally developed black crusts similar to those found on diseased roots.

Further examination of these blocks has not been made. They are being kept to see if they will develop fruit bodies. It is further proposed to use such blocks for infection experiments on living trees during the coming year.

Large numbers of plants have been examined in the field and cases of the disease have been found on *Coffea*

arabica, *C. robusta*, Tea, *Tephrosia candida*, *Erythrina* and *Grevillea*. The fungus has also been noted on a number of jungle stumps so far unidentified. As was mentioned in the last report, the disease is almost always associated with rotting stumps. In fact, apart from the cases mentioned last year from the Shevaroys, the association with rotting stumps has always been found to occur.

In order to study the relationship to stumps more clearly, a young Robusta plant (Fig. 1) which had succumbed to the disease in an area at the Experiment Station was washed out of the soil with fine jets of water under pressure. A trench was dug three or four feet away from the tree and the soil gradually washed down into it, from which it was removed. As far as possible, the roots were kept intact. The plant was eventually extracted with its root system almost complete.

The signs of the disease were found from the collar to a depth of nine inches on the tap root, while all the lateral roots arising in this region were diseased for a distance up to four inches from their point of origin. There were, however, two exceptions to this; two of the roots were diseased for much greater distances from the tap root and in each case it was found that these two roots were in direct contact with the rotting roots of a neighbouring stump.

The contact of the larger of these which was the most readily examined was at a depth of about twelve inches from the surface and about twenty inches horizontally from the tap root. When first exposed, this diseased root was firmly cemented to the stump root (Fig. 2).

The roots beyond the diseased portions were apparently quite healthy, the fine feeding rootlets were white and turgid and the woody roots showed no signs of disease. A description of the extent and type of the root system will be given below.

It is proposed to extend such work to other diseased trees in an effort to obtain further knowledge of the mode of spread and of the limits of depth to which the fungus penetrates.

A start was made on testing soil acidities in areas where the disease is widespread. So far only a few results have been obtained and they do not afford sufficient data for discussion.

As far as present knowledge goes, the only sure way of dealing with root disease is the eradication of rotting

timber from the soil. This is very expensive and can rarely be done over a large estate, but wherever the disease appears, it is very desirable that the patches infected should be thoroughly cleared of centres of infection.

Of other root diseases, mention may be made of *Rosellinia* which is probably the second most common source of root disease. This has been found on coffee and *Grevillea* at the Experiment Station as well as on a number of jungle tree stumps. The disease is easy to distinguish by the greyish black woolly mycelium visible on the surface of the diseased roots. Very commonly, the black pellet-like fructifications can be found in large numbers on neighbouring stumps. The ones so far examined place the fungus in the species *Rosellinia arcuata.*

Methods of treatment would follow the same lines as for *Fomes* but special care must be taken to destroy all mulch and small twigs in a diseased area as this fungus seems to spread more rapidly than the *Fomes*, the extension of which is usually by contact of healthy roots with diseased timber.

Leaf Disease. Progress Report.—Field observations on Leaf Disease carried out during 1929-30 were continued throughout the year under review. A report on the first year's work was published as Bulletin No. 4 of the Mysore Coffee Experiment Station under the title "Seasonal Periodicity of Coffee Leaf Disease." A further report on the second year's work, confirming and extending the results of the first year, is in preparation.

In addition, work on Leaf Disease has been carried out in the laboratory on spore germination and infection. The results are very incomplete and the experiments are hardly out of the preliminary stage.

I. *Spore Germination.*—As reported last year, germination of the uredospores is not very regular or plentiful on glass slides, but better results have attended some of the experiments carried out during the present year. With the more complete standardization of conditions, it may be possible to use this method more extensively than was at first expected. Preliminary experiments show that the acidity of the water used, the humidity of the surrounding air and the illumination are factors of extreme importance in determining the amount of germination. It is highly probable, though no experiments have yet been made on

this point, that the age of the pustules from which the spores are obtained and the climatic conditions at the time of collection are also of importance. These will be considered in future studies.

The problem of spore germination was also attacked along a different line, in the hope that more regular results would be obtained. Spores were sown in drops of neutral distilled water on the undersides of detached coffee leaves. These coffee leaves were supported on dishes containing distilled water and the whole covered by small bell jars lined with moist filter paper.

Experiments on these lines were conducted in the daylight and in the dark, with short periods of illumination. In some cases, the drops of water containing spores were allowed to dry by raising the bell jars slightly. After twenty four hours (in some cases forty eight hours), the leaf surface covered by the drop was cut off as a thin section and the number of germinated spores counted. Records were also kept of the type of germination—whether the germ tube was branched or unbranched and whether any penetration of the leaf had occurred. It is too early to discuss the results but it may be said that so far they agree with those of the previous worker who used this method.

Work will be continued along these lines during the coming year.

II. *Inoculation.*—Some experiments were made in an endeavour to reproduce the disease in the laboratory on young potted plants. The experiments were all failures. The most likely source of this failure lies in the water used for the spore suspension, which was found to be highly alkaline. It may be also that the spores are in some way injured by being made into a suspension with water. In future experiments it is proposed to dust spores on to the moistened leaves instead of spraying leaves with a spore suspension.

Experiments were started in the laboratory along the same lines as those used for studying spore germination except that the leaves were left with their petioles in water for periods up to three weeks to see if disease pustules would develop. None of these preliminary experiments gave a positive result. This work will also be continued in the future.

III. *Age of the Leaf and Infection.*—In the course of one series of observations carried out during the year,

a large mass of data was collected from which it will be possible to obtain an idea of the minimum age at which leaves become infected. These data have not so far been analysed with respect to this question but the work will be taken up during the coming year.

Flower and Fruit Studies. Progress Report.—Studies have been commenced on various aspects of flower and fruit production, crop loss and setting.

I. *Pollen Germination*:—In order to gain some knowledge of the conditions affecting the viability of pollen and the possibilities of storing it for longer or shorter periods, work was commenced at the blossom time of 1930. The subject was taken up in view of its great importance in connection with the breeding work in progress at the Experiment Station. Investigations were continued at the blossom time of 1931.

The first year's studies were purely preliminary, to obtain an idea of the most suitable fluid for germinating the pollen grains as regularly and as normally as possible and to examine the behaviour of pollen on keeping it in sealed tubes in dry and in moist air.

Like the pollen of many other plants, coffee pollen will germinate in water and in cane sugar solutions. Tests were carried out with distilled water and cane sugar solutions ranging in concentration from five per cent to fifty per cent. The best results were obtained in a twenty per cent cane sugar solution and this was used in all the later work.

The results so far obtained with fresh pollen show that healthy pollen from Kent's Arabica flowers will give between forty and fifty per cent germination in artificial culture. The amount of germination is increased somewhat by the addition of small fragments of stigmas, provided that the stigmas do not come from the same flowers as the pollen.

It was found that flowers brought out early in the year, *e.g.*, Middle of March, gave much less viable pollen than flowers that blossomed later. The following data illustrate this point:—

Date	Mar. 14	Mar. 16	Mar. 17	Mar. 18	Mar. 19	Mar. 23	Mar. 24	Mar. 31
Percentage germination ...	16·9	7·3	12·6	25·0	21·8	50·5	53·5	42·8

The last date was the date of the general blossom, the pollen used on the earlier dates being from plants forced out by watering. The pollen was collected at the same time of day on each date and the tests were all carried out in the same way. Not less than two and usually four separate hanging drops were examined in each experiment. Further work on this point is planned for the future. Tests of pollen viability of blossom brought out by February rains would be of some interest in this connection.

The experiments with stored pollen gave somewhat conflicting results but it was found that healthy pollen preserved in a perfectly dry atmosphere could be kept for at least four days without marked loss of viability. Under ordinary air conditions, viability of the pollen is rapidly lost. Further work on the preservation of pollen is planned for the future in which it is hoped to make tests on the fertilizing power, as distinct from the germinating power of fresh and stored pollen.

The discovery at the end of the year that a number of the hybrid plants in the selection plots at the Station produce little or no pollen renders it necessary to make a survey of the selected plants for pollen formation and to test the viability of such pollen as is produced by them at the next blossom period.

II. *Fertilization.*—A commencement was made at the end of year (1931 blossom) to study the time required for fertilization to be effected. At the blossom period, flowers were removed at regular intervals, from the time of opening up to seven days afterwards. The ovaries of these flowers were fixed in weak Flemming's solution and embedded in paraffin. These will be sectioned when opportunity offers and the sections examined to trace the process of fertilization. Young fruit initials which were turning yellow and falling were similarly fixed and embedded to see if the failure is connected with lack of fertilization.

III. *Crop Losses during Development.*—In connection with a detailed series of observations on crop bearing branches carried out to gain information about Leaf Disease and leaf fall, records were kept of the amount of flower bud formed and the times of loss of young fruit.

The observations were in two sets, one set of sixty crop bearing branches, twenty from each of three plots receiving a post monsoon spray and a second set of sixty from three

plots which were unsprayed. The crop in the area was poor but blossom showers were favourable both as to time and amount. The results are summarized below.

	Sprayed.	*Unsprayed.*
Healthy Bud. 31st March 1930 ...	958	934
Loss After Blossom	292	515
May-June	108	60
September-October ...	135	68
Unswollen Fruit ...	108	74
Total Loss ...	643	717

It can be seen that by far the greater part of the loss in these observations occurs in the early stages. This early loss takes place before the fruits have begun to swell and constitute the "shanking" which can always be seen shortly after the blossom period. With this may be associated the loss due to the failure of swelling. These young fruits may remain on the tree throughout the season and in the first few weeks cannot be distinguished from the future fruit until the healthy ones begin to swell.

A second form of loss made itself apparent at the end of May and early June. This affected young fruits which had started to swell and had reached a length of about a quarter of an inch. It was first noted that some fruits seemed to be lagging behind the rest and then large numbers of such small fruits were found on the ground. The outward signs, apart from the difference in size, were very few. Sometimes young fruits about to fall could be recognized by a blackening of the stalk but this was not always so. Small fruits could often be picked up from the ground in which there was no external sign of anything wrong. On cutting open such fruits, it was found that one or both the young beans were black and rotting, while the surrounding tissue remained green. The loss in those observations amounted to a little less than twenty per cent of the healthy fruit remaining on the branches on 26th May. A report received from one estate in the Bababudans gave a much higher estimate of the loss of crop due to this form of failure. Experiments to ascertain whether the phenomena observed were due to fungi or bacteria gave negative results, but they were not sufficient in number to draw any definite conclusions. It is hoped to investigate this point more fully next year.

The later loss of crop was due almost entirely to Die Back following a severe attack of Leaf Disease during the monsoon. Some observations made in November in the plots from which these branches were selected showed that between 65 and 75 per cent of the crop bearing branches had begun to die back at the tips before the crop was ripe. This Die Back nearly always resulted in the drying off and falling of the fruit nearest the tips. A discussion of the relation of this Die Back to Leaf Disease has been given elsewhere. Preparations have been made for following the course of crop losses during the year on a larger scale during 1931. The first count at the end of the present administrative year involved nearly ten thousand buds. Records are being kept, at least during the pre-monsoon period, at weekly intervals. This new series is being carried out in twice sprayed coffee under as even shade conditions as possible and the records are arranged so that the results can be treated statistically. It is hoped that losses due to Leaf Disease and Die Back will be eliminated by the spraying and attention can be concentrated on other causes.

No doubt a great deal of the loss in the early stages is inevitable but the peculiar loss in late May and early June in 1930 deserves closer investigation, especially in view of the recent work on coffee crop loss in East Africa.

If observations of this type can be carried out for a number of years, a good deal of light should be thrown on the effect of climatic conditions on crop setting.

The fruits which ripen in the series just commenced will also be examined for "jelloo" or empty berries and on the basis of data so obtained, it may be possible to institute work which will throw some light on this obscure condition.

Coffee Root Systems.—Our knowledge of the root system of coffee is very slight, being limited almost entirely to scattered observations made during digging work or in extracting trees which have died from one cause or another. This is primarily due to the inaccessibility of the root system for the purposes of study and yet a knowledge of its extent both laterally and vertically, its mode of growth and its variation under different conditions cannot but throw light on problems of cultivation, manuring, spacing and the selection of shade.

A commencement was made during the year on a study of the distribution of the root system in the soil. The first attempt was undertaken primarily in connection

with root disease but on unearthing the plant the root system was so complete that a comprehensive series of measurements was made as a preliminary to further work with healthy plants.

The tree was Robusta of about four years old which had been topped at two and a half feet and bore four pairs of primaries with a spread of about six feet from tip to tip. The root system was extracted in its entirety by washing the soil away with fine jets of water from a trench dug at some distance from the plant.

A neighbouring healthy Arabica plant of five years old was similarly treated and measurements taken. A brief summary of the data obtained is given in the table so that the differences can be appreciated.

	Robusta.	Arabica.
Circumference at collar ...	6 ins.	4½ ins.
Tap root	3 ft. 5 ins.	2 ft. 2 ins.
1st Lateral. Depth ...	3 ins.	4½ ins.
No. of woody laterals ...	66	57
Longest lateral	6 ft. 2 ins.	5ft. 6 ins.
Average of main laterals ...	5 ft. 3 ins.	4ft. 6 ins.
Greatest concentration of laterals on tap root.	6 ins—9 ins	10½ ins—13½ins.

It may be noted that the lengths of the roots given are on the low side as it was rarely possible to follow the large roots to their extreme tips. The tap roots in both cases were probably at least six inches longer.

It is impossible at this early stage to discuss all the data in detail but two points stand out from these observations and measurements. One is the much greater development of the Robusta root system when compared with that of the Arabica. The differences are really much more marked than are shown by the figures given in the table. Thus in the region between six inches and one foot from the collar in the Robusta plant only six out of twenty six laterals are less than three feet long, while in the same region in the Arabica twenty two out of thirty two fall into this category. Further, no records were made in these observations of the amount of branching, which was much more profuse in the Robusta.

The second point is that on the average, the main lateral roots of the Robusta originated nearer the surface than those of the Arabica and it appeared in the course of washing out that they grew in a more horizontal direction in the former. Thus, on dividing up the tap root into

three inch intervals and recording the number of laterals in each division, the following figures are obtained :—

	Collar to 1st lateral	No. of laterals 3 inches below first	No. of laterals 6 inches below first	No. of laterals 9 inches below first	No. of laterals 12 inches below first	No. of laterals 15 inches below first
Robusta ...	3 inches	13	19	7	7	9
Arabica ...	4½ inches	15	15	17	7	3

The Arabica has no woody laterals after eighteen inches, while the Robusta has eleven such roots between eighteen inches and three feet six inches though none of them is very large or profusely branched. It can be seen that the greatest density of laterals is somewhat lower in the Arabica than in the Robusta.

The extent of the root systems of both types shows that the root system of neighbouring trees with the usual planting distances employed in this country is inextricably mingled and that below a depth of about 6 inches the soil must be completely occupied by the coffee roots.

These studies will be followed up with the washing out of more trees of both types under varied conditions of soil and cultivation.

Spraying Materials and their Effects on Leaf Fall.— An attempt was made to obtain data from leaf counts made in areas receiving different types of spray mixtures which would throw light on their relative effectiveness in controlling Leaf Disease and leaf fall.

Observations were started at the end of September 1930, when the disease was very widespread in unsprayed areas. It was found possible to utilize crop bearing branches of fourteen to eighteen internodes and to find sufficient numbers in the plots to give data for statistical analysis. In each plot twenty crop bearing branches of the required age together with their associated shoots were examined and the total number of leaves counted for each one of the 20. It was found that twenty branches of the type used, bore on the average one hundred and fifteen side shoots. The variation in this figure was surprisingly small. From the number of leaves and the number of growing shoots, a figure for the number of

leaves per growing shoot was obtained for each branch unit. The Mean and the Standard Deviation were calculated for each treatment and from them, the Standard Error.

The data were collected for thirty different plots, representing ten different treatments. The results were as follows :—

Check	2·40±·13
Casein Bordeaux	5·90±·18
Resin Soda Bordeaux	5·50±·16
Linseed Oil Bordeaux 10 ozs. ...	6·35±·21
Do do 20 ozs. ...	6·09±·19
Do do 40 ozs. ...	6·28±·25
Alum Bordeaux	5·38±·24
Resin Soda Burgundy	4·87±·18
Fish Oil Resin Soap Burgundy ...	5·57±·13
Three per cent Solbar	3·10±·11

For further comparison, two similar sets of observations were made at Guntanaik Estate on an area receiving, in one part Full Strength Casein Bordeaux and in the other Half Strength mixture with the same adhesive. The results were as follows :—

·5 per cent Casein Bordeaux ...	5·42±·20
1·0 do do ...	5·81·±14

In interpreting the results of these observations, several difficulties present themselves due to the fact that there are at least two sources of error which are not common to all the plots. These are :—1. The varying efficiency of the coolies carrying out the spraying on the different plots. 2. The possibilities of rain falling when some of the plots are still wet from the spray, while others done at some other time may have dried and not be so susceptible to washing.

In view of this, several other series of observations will be necessary before the differences between the plots can be regarded as significant even where the present differences may be greater than twice the Standard Error, the usual test of significance.

However, in the case of Solbar and the Check plots the differences are quite large enough to be considered as definite. With a little less assurance, the data for Resin Soda Burgundy may be considered as fairly conclusive, especially as the reports from the Shevaroys for this mixture were unfavourable. The other data are not definite, though the figures for Linseed Oil are promising.

This adhesive in the ten ounce strength is certainly worth trial, if only because of the case with which it can be employed. It is simply poured into the mixture and thoroughly stirred.

From the results of the spraying at Guntanaik, it can be seen that there is very little difference in the results from spraying with half and full strength. This, together with evidence from other areas receiving a half strength spray, suggests that the half strength mixture is a sufficient protection. This is still further supported by the fact that the year in question was a very bad one for early Leaf Disease in the district where these observations were made. Conditions were eminently favourable for revealing weaknesses in spraying materials, methods and times.

These observations will be repeated in the coming year and it is hoped that a second set of figures will enhance the value of these observations very considerably.

Green Bug.—In the Report of the Coffee Scientific Officer for 1929-30, mention was made of some experiments started to try the effects of providing young coffee plants with sticky bands to keep off ants and to see whether sufficient control of the ants could be obtained in this way to effect a reduction in the Green Bug.

In a clearing of coffee about eighteen months from planting at Kolar Estate, North Mysore, 493 plants were provided with bands of Grease proof paper covered with "Ostico" on February 19th, 1930. At the time of application, these plants were classified for the severity of Bug infestation and a further 463 plants left without bands were similarly examined. A second examination was made in May 1930 with the results given in the table below :—

	February		May	
	Banded	Unbanded	Banded	Unbanded
	Per cent	Per cent	Per cent	Per cent
Free or very slight attack.	58·1	59·6	57·8	61·9
Slight attack ...	30·6	28·4	22·7	17·8
Severe attack ...	10·1	10·3	12·3	14·6
Very severe attack ...	1·2	1·7	7·2	5·7

The results unfortunately give very little information since the increase in the Bug attack during the period was almost negligible.

It may be remarked that the banding material is efficient in trapping ants, provided it is not earth plastered or very wet. In the presence of alternative routes up the plant, *i.e.*, weeds, fallen branches, low hanging shade, etc., the banding material is obviously ineffective as the ants rapidly learn to profit by them. At the May observation, it was found that about ten per cent of the banded plants showed such alternative routes across which ants were moving. The remainder were free of ants and dead ants were found on about twenty five per cent of the bands. The material was still sticky after three months but during rainy weather, the surface of the Ostico loses its stickiness and is then also ineffective.

Costs.—An approximate calculation of costs gave the following figures :—

	Rs.	a.	p.
Ostico (16½ lbs. at Rs. 1/8. (plants 1 in. diam)...	24	12	0
Paper 180 yards at Rs. 3 per roll of 200 yds. ...	2	12	0
Twine about 800 yards ...	0	12	0
Labour 15 coolies at 6 annas ...	4	14	0
Total per acre ...	33	2	0

In addition, there would be a slight addition of commissions and also the cost of removing the bands, for it was found that the gunny twine used was preserved by the Ostico and the plants were liable to be damaged if the bands were left on for a long time.

In view of the cost alone, it does not seem that this offers a very promising means of controlling ants and Green Bug. In any case, it could only constitute a partial control.

In a recent bulletin of the Kenya Department of Agriculture (H. C. James. The Repellent Banding to Control the Ants Attending the Common Coffee Mealy Bug.), a detailed account is given of experiments along similar lines on old coffee. The figures given for costs of application are very high and quite out of the question for S. Indian conditions. In addition, the point is made that banding alone without more direct methods (in this case, Biological control) is not likely to be of great service.

It is possible that if a much cheaper and equally repellent material was available, banding might be of some

limited use on young clearings but it could never be extended to old coffee under South Indian conditions.

Cockchafer.—In the absence of this pest anywhere near the Experiment Station, practically no work has been done up-to-date. Some specimens of the grubs were received and placed in pots with young coffee plants but up-to-date no damage has apparently been done to the plants and no adults obtained. These will be kept under observation.

Arrangements are being made for a visit to an infested area for an extended period.

General Notes.

Manuring.—Questions of the manuring of coffee form a considerable part of the enquiries received. Recommendations have been made invariably on the basis of the work of the Mysore Agricultural Chemist at the Station and elsewhere. I owe him my thanks for his assistance on many occasions.

The main features of the suggestions are that as far as a quick return for expenditure goes, artificial concentrated manures are to be preferred to organic and other slow acting manures. This is especially the case in respect to sources of Phosphate.

The ratio and amounts of the various plant foods in a complete mixture have been discussed in Dr. B. Narasimha Iyengar's bulletin, "The Improvement of the Coffee Industry in Mysore," published by the Mysore Agricultural Department. These data have been used in suggesting mixtures.

Spraying.—Many enquiries have been received with regard to spraying materials, machinery and time of application. These have all been dealt with in detail on the basis of the experience gained at the Station and on estates where spraying has been carried out for a long period.

A point that is often overlooked in the preparation of the mixture is that the method of mixing the components is a matter of considerable importance. In the case of Bordeaux, the addition of the Copper Sulphate solution to the Lime solution is much to be preferred to adding the Lime to the Copper Sulphate. It has been found both in the laboratories of the Mysore Department of Agriculture and elsewhere that pouring a weak Copper Sulphate

solution into a strong Lime solution is the best method of preparing the mixture. This presents very considerable difficulties on an estate scale so that a compromise is necessary. This is the addition of a strong Copper Sulphate solution to a weak solution of Lime and this method should always be employed. This is the usual method in use on estates but not without exceptions.

In the preparation of the half strength mixture, the actual quantities per barrel should be measured out. The product obtained by diluting a full strength mixture with water is very considerably inferior in the suspension of the particles of fungicide.

A ready mixed Burgundy powder tested was found very inferior to the home made mixture, as far as the fineness of the particles, on which a good deal of the fungicidal power depends, was concerned.

Bordeaux and Burgundy mixtures are not simple cases of chemical action between Copper Sulphate and Lime or Soda, but complex reactions involving the production of a wide series of basic Copper Sulphates formed in varying proportions under different physical conditions. Matters are further complicated by the fact that the form of the precipitate produced by the interaction, whether fine or coarse, also depends on the physical conditions of preparation. It is this last factor which is very important in producing a spray cover of high efficiency.

Fungus Diseases.—In addition to the diseases already mentioned in connection with investigations, a number of cases of minor injury by fungi have been reported, and, where necessary, suggestions have been made for treatment.

Nursery Collar Rot.—This disease appeared in one of the nursery beds at the Station in the early part of the monsoon. Isolations made from the diseased tissues gave a *Rhizoctonia*. The disease seems connected with overcrowding and excessive moisture and only under such circumstances does the fungus become virulent. Thinning out and keeping the beds drained will serve to prevent the appearance of this disease. The application of a Bordeaux spray will prevent further spread if the disease has appeared.

Cercospora Leaf Disease.—A spotting of coffee leaves associated with *Cercospora* has been met with fairly frequently, especially in young plants in the nursery. It never does much damage but if necessary can be

controlled by Bordeaux spraying. Like most fungus diseases, it begins to show up with the first rains.

Hemileia vastatrix.—In addition to the widespread occurrence of Leaf Disease on Arabica Coffee, a number of reports and specimens of the fungus on Robusta have been received. Although the majority of Robusta plants appear to be highly resistant to Leaf Disease, there are usually a number of susceptible plants in most Robusta plantings. If these can be picked out in the first year or so, it seems to me that it would be advisable to eliminate them and replace them by resistant plants. It is hoped to investigate the question of resistance to Leaf Disease in future work. It has been suggested that Robusta may lose its power of resistance and while this is purely speculative, it seems advisable to collect all records of the disease in Robusta areas so that a watch can be kept for any signs of spread.

By the kindness of Mr. Narasimhan, Mycologist, Mysore Agricultural Department, some specimens of *Gardenia gummifera* were received from Sagar in the Shimoga District which bore orange yellow pustules. On inspection, the spores were identical in size and shape with those of *Hemileia vastatrix.* It is hoped to test whether this fungus is identical with that occurring on Coffee in future work.

Root Disease of Tephrosia candida. Specimens of a root disease which differed in several particulars from those commonly found on woody plants in estates were received during the year. The characteristic feature was the presence of a collar of brown spongy tissue at the soil level, which bore large numbers of basidiospores on its surface. Complete identification was not obtained, though the fructification was of a *Corticium* type. The control measures suggested were the uprooting of all diseased plants.

Leaf Disease of Erythrina.—A considerable amount of Leaf fall was noted on Dadaps during the monsoon. The leaves bore small brown to purple spots and when severely attacked, the leaves turned yellow and fell. A fungus with dark four to five celled spores was found in the tissues. These spores were borne in receptacles (pycnidia) and the fungus therefore belongs to the form genus *Hendersonia.* The disease disappeared at the end of the monsoon and the trees put out fresh leaf. No control measures seemed called for.

Insect Pests.—Reports during the year have indicated that both the ordinary white borer (*Xylotreches quadripes*) and the shot hole borer (*Xyleborus* spp.) of Robusta have been especially severe. No work has been done on these pests and little can be added to what has been written in the past. Extensive work on the former pest has been reported by Dr. Kunhi Kannan, the Mysore Government Entomologist, but so far there seems nothing new which can be recommended for use on a large scale. The shot hole borer was exceptionally severe after the monsoon of 1930, and much damage was done to young plants in which the primaries were attacked and the suckers left to raise the height of the trees. A few cases of infection of Arabica trees standing near Robusta areas were seen. Observations suggest that shade is an important factor, heavy shade encouraging the spread of the pest, and consequently it is advisable to keep the shade as light as possible in Robusta areas.

Of minor importance are cutworms, for which treatments were given in the report for 1929-30, slugs gnawing young fruit during the monsoon and red borer (*Zeuzera coffeae*) in young plants and in small branches of older plants.

A case of a seed bed of Robusta in which seeds failed to germinate revealed the presence of mites which had invaded the seed and destroyed the embryo. In some cases, the seed was quite intact and apparently healthy except for a minute puncture at the embryo end and the absence of the embryo. Mites were constantly found in the cavity left by the disappearance of the embryo. It appeared that the mites were seed borne or came in the bags with the seed. No further report of this type of pest has been received.

Root Mealy bug continues to give trouble on one or two estates in Coorg. Work will be taken up on this pest in the coming year.

Specimens of suspected *Stephanoderes* have been received from various estates and invariably despatched to the Mysore Government Entomologist. The situation with regard to this pest is still obscure and none of the specimens received were identified as *Stephanoderes Hampei.*

Future Programme.—Work will be continued along the lines laid down in the previous section of the report dealing with investigations in progress.

In addition, it is hoped to commence work on Cockchafer and Mealy bug in Coorg during the coming year.

Correspondance, Meetings.—Two hundred and eight letters have been received during the year and 188 despatched. As has been pointed out in the report, the majority of the enquiries received have to do with spraying and manuring.

Meetings of the Advisory Board of the Coffee Experiment Station and of the Mysore Planters' Association have been attended. An outline of the work in progress was given at a meeting of the Shevaroy Planters' Association in July 1930.

Acknowledgments.—I should like to take this opportunity to express my deep sense of gratitude to Dr. Coleman and the members of his staff for their unfailing kindness and help during the year, and also to the many planters with whom I have had the opportunities of much fruitful discussion.

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